NAVAL ELECTRONIC LABORATORY CENTER, SAN DIEGO, CALIFORNIA 92152

A DIGEST OF RESEARCH APPLICATIONS

FOR THE ADVANCED COMMAND CONTROL ARCHITECTURAL

TESTBED (ACCAT)

27 July 1976

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REPORT SUMMARY

This note presents 44 possible research applications which result from a match-up of Navy command control problems with recent research results. Several of the more promising applications will be selected for demonstration on the Advanced Command Control Architectural Testbed (ACCAT) located at NELC. In selecting the applications, we were interested in those areas of research which could be demonstrated quickly to permit an early assessment of the technology.

In the hierarchy of Naval Command Control, we are concerned with command control problems at the Fleet Commander-in-Chief and Tactical Flag Commanders level. The functions and basic command control processes of these two nodes are sketched herein.

The technological research areas which were used in the matching process were limited to the following four areas: Artificial Intelligence, Data Base Management, Query Systems and Decision Aids. In this initial effort we concentrated on work funded by the Information Processing Technology Office of ARPA, and by the Information Systems Program and the Operational Decision Aids Project of ONR.

PURPOSE

A series of brief descriptions of possible demonstrations for the ACCAT program was produced. Only those technologies which seemed to have ready application to Navy Command Control problems were included. This is an initial digest and as such will undergo several levels of reviewing before final demonstration selection is made.

ADMINISTRATIVE INFORMATION

ACKNOWLEDGEMENT

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1.0 INTRODUCTION

This note reports on some of the work performed by Code 3300 under NELC Task J732630. The task had the tripartite goal of identifying an ARPA and ONR funded technology baseline, reviewing Navy C^2 system, and identifying possible demonstrations of the applications of these technologies to Navy C^2 systems. The demonstrations are to be performed on the Advanced Command Control Architectural Testbed (ACCAT) being installed in the EDATL building at NELC. The ACCAT is discussed at length in reference 1. This initial presentation of the technology baseline was limited to a few areas funded by the Information Processing Technology Office of ARPA, and by the Information Systems Program and Operational Decision Aids Project of ONR.

In selecting applications for possible demonstrations we were interested in those areas of research which could be demonstrated quickly to permit an early assessment of the technology. A process of increasing the depth and breadth of the experimentation can thereby be followed in the technology evaluation process. This process can expect to be truncated when either the expanded scope of the experiment no longer yields an increase in demonstrated performance or the techno-logy issue is clearly ready for transition to more advanced stages of development.

2.0 TECHNOLOGY BASELINE

The technologies addressed for possible application to Navy command control problems were Artificial Intelligence (AI), Data Base Management, Query Systems and Decision Aids. Although part of our task was to review these technology areas it is impossible in this note to present anything but a brief description of each area.

2.1 Artificial Intelligence

Feigenbaum[2] defines artificial intelligence research as follows. "Artificial Intelligence research is that part of Computer Science that is concerned with the symbol-manipulation processes that produce intelligent action. By 'intelligent action' is meant an act or decision that is goal-oriented, arrived at by an understandable chain of symbolic analysis and reasoning steps, and is one in which knowledge of the world informs and guides the reasoning".

Subsets of AI which appear to have immediate applications are knowledge-based data systems and production systems. In knowledge-based data system develop-ment the emphasis is " ... upon the encoding of knowledge about the world in symbolic expression so that this knowledge can be manipulated by programs; and the retrieval of these symbolic expressions, as appropriate, in response to demands of various tasks".[2] A production system is a collection of production rules, a rule interpreter and a data base. A production rule[3] is a statement of the form

$$\text{If: } predicate_1 \text{ and } predicate_2 \text{ and } \ldots \text{ and } predicate_m$$

$$\text{then: } action_1 \text{ and } action_2 \text{ and } \ldots \text{ and } action_n$$

Depending on the particular strategies incorporated in the rule interpreter, or monitor, the actions are (at least potentially) performed when all the

predicates are true. The predicates test various objects and their attribute values within the data base. The intelligent terminal agent project at Rand operates using a sophisticated production system.

Examples of knowledge based data systems are Meta-Dendral[2] and Mycin[2]. The former is a molecule structure generator and the latter is a medical diagnosis and therapy advice system. Both of these systems were developed by close collaboration between experts in the field and AI researchers. Each system has been "custom crafted."

2.2 Data Base Management System

Data Base Management systems are developed and marketed today under various generic names. Such appellations as data management system, generalized information retrieval system, information management system, and file management system are the main terms in use. The more elementary systems search a sequential file having simple record structures and provide only rudimentary report formatting facilities. More elaborate systems handle several files via indexes or links and function in an on-line mode. With each system there may be a special command language and an individual data structure.

The special command language enables a user to update and access the data base. In general one must have detailed knowledge of what is in the data base together with the structure. Even armed with this knowledge selective updates and retrievals can be both cumbersome and time-consuming.

The research in this area has two major thrusts, one of efficient manipulation of very large data bases (i.e., computer-held files of greater than 10^{11} bits) and the other of utilizing existing data bases in an effective manner. Both of these areas could have impact on C^2 systems. Different methods must be used to manipulate and access very large data bases since access time becomes the critical feature. Naive extensions of textbook data manipulation tools may lead to unsatisfactory response times.

An important effort in making data bases easier to use is work being done in Relational Data Bases. In a Relational Data Base data are (conceptually) stored in two dimensional matrices called relations. Each row and column has a name and associations between records (rows) are represented solely by data values in columns drawn from a common domain. For example we could have the following relation in a data base.

HULL #	SNAME	LENGTH	LOCATION
7	CRAIG	250	Newport
25	JONES	300	San Diego
964	FOSTER	350	Newport

Using relational algebra we could

"Find SNAME for ships in Newport."

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This would create a relation

SNAME
CRAIG
FOSTER

Two other methods of effective utilization of data bases are concerned with setting "alerts" which notify the user that preset thresholds have been exceeded, and searching the data bases to detect preset patterns in the data. Efforts along this line are the large File Management Information Systems[4] project at Stanford Research Institute (SRI) and the Decision-Aiding Information System (DAISY) at the University of Pennsylvania. The DAISY[5] system has other capabilities other than setting alerts, as its name implies it is a decision aiding system.

2.3 Decision Aids

A decision aid is a resource used by a decision maker which either facilitates the making of decisions, improves the quality of decisions, or improves the consistency of decisions. The decision aid may be a person, or group of persons. The technological thrust is toward the use of mechanical decision aids. These can range from query systems which make information available to the decision maker, to automata which can be trained to make decisions for the decision maker (comparing observed events with prestored criteria). A sophisticated decision aid can provide measures of optimization - normally through maximization of the decision maker's expected utility. Decision making under uncertainty is enhanced by use of a decision aid which will systematically apply the axioms of probability. Automated decision aids can be constructed with a ready access to stored data, and the ability to make mathematical calculations and logical manipulations. Such aids can be very quick and very consistent. The decision maker must provide subjective estimates of probability, and must provide measures of personal preference on which utility assignments can be based. The human decision maker normally monitors the actions of the mechanical decision aids, and usually exercises his experience, intuition and judgement in accepting or modifying courses of action offered or suggested by the decision aids. Work in the theory and application of mechanical decision aids is being actively pursued by Perceptronics, Inc., Decisions and Designs, Inc., Stanford Research Institute and other organizations.

2.4 Query Systems

Query Systems or natural language processors as they are sometimes known, permit the noncomputer scientist user to easily access data bases. Design goals for these systems are to provide a robust man/machine interface which will enable a user to obtain information with a minimum of jargon learning. Some systems have a fixed list of English-like commands which are recognized. Others can be quite sophisticated in terms of the complexity of syntax recognized. For example a simple system could answer the following questions:

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    a.   Where is the FOSTER?

    b.   Where is the KENNEDY?

where the FOSTER and KENNEDY are ships, and positional information about them is stored in a data base. A sophisticated system could answer the following incomplete set of sentences:

    a.   Where is the FOSTER?

    b.   The KENNEDY?

    c.   How soon to rendezvous?

Of course as the sophistication of the systems increase so does program complexity and storage. Work in this area is being done in the PLANES system at the University of Illinois, LUNAR systems at Bolt Beranek and Newman (BBN) and the SHRDLV program at MIT.

3.0 COMMAND CONTROL FRAMEWORK

This section presents tentative information on the NCCS architectural framework and the macro relationships of a C^2 node in the total network.

3.1 Nodal Description

The architectural elements of the Navy Command and Control System (NCCS) can be categorized into ten subject areas which pertain to the node (where the C^2 function is exercised) and the network (within which the nodes are provided connectivity). These elements are as follows:

    . Command Facilities
    . Communication Systems
    . Warning/Sensor Systems
    . Reporting Structure
    . Personnel and Procedures
    . Data Processors
    . Data Bases
    . Application Programs
    . System Programs
    . Man/Machine Information Couplers

The last five aggregate to Automatic Data Processing (ADP) facilities which are exercised within the nodes and are of further interest to this note. Figure 1 illustrates the relationships of the elements of the C^2 network and the nodes.

The nodes of the NCCS may be characterized in terms of four basic command and control processes. They are:

    Information Input Process
    Situation Assessment Process
    Decision and Direction Process
    Report Generation Process

The impl   ntation of these processes at the various NCCS nodes will be dependent on

   a.   The nodal mission and location within the command hierarchy.

   b.   The time frame in which the node is viewed.

However, the processes themselves are invariant with respect to node and time frame, and can be characterized by subprocesses which are generic in nature and nodally independent.

3.1.1   Information Input

The Information Input Process is the front end processing function which, in effect, prepares the information for use by a man in either the Situation Assessment or Decision and Direction Process.

3.1.2   Situation Assessment

The Situation Assessment Process is the process in which own force missions and tasks are analyzed with respect to own and enemy capabilities, and potential enemy courses of action (COA). The resulting estimates of the situation become the major input to the Decision and Direction Function. Situation Assessment is a continuous monitoring and evaluation process, and its results may modify existing data base information or create new information.

3.1.3   Decision and Direction

The Decision and Direction Process formulates and analyzes alternative courses of action to accomplish assigned tasks and missions in the face of potential or actual opposition. The output of the Decision and Direction Process may change the operational assignments/status of assigned assets.

3.1.4   Report and Directive

The Report and Directive Generation Process provides the means by which a command node passes information, orders, alerts, queries and requests to external nodes. The process is not confined to handling information developed after a particular decision has been made; it provides a means of immediately outputting to cognizant commands, critical information received and identified by the Information Input or Situation Assessment process.

3.2   Principal Function Description

The above nodal discussion can be presented in terms of principal functions ordered with respect to an event-action-reaction time line which would be a typically stressed environment for an NCCS Command Center.

3.2.1   Alerts and Notifications

An alert is a received warning of an impending mission and the notification is the command center response. This function involves procedures and methods

for receiving, processing, and distributing alerts. Through a combination of hardware, software and audio/visual alarm, the Watch Officer 's assisted in performing alert/notification functions.

3.2.2 Operational Evaluation and Threat/Situation

This function provides event summaries of own forces and threat forces. It incorporates situation correlation of environment, Red Track position, and Blue Track position.

3.2.3 Operation/Resource Availability Planning

This function details readiness status and performance characteristics of Blue and Red resources, including presonnel, facilitites, weapons, and plat-forms. It provides operational status regarding location, situation, employment category, etc.

3.2.4 Current Operational Planning

This function encompasses aids in developing mission plans, the development of alternatives courses of action (COA's), the determination of resource require-ments, the allocation of resources, logistic determinations, and planning for decision execution.

3.2.5 Execution

The execution function provides tasking orders and directives for resource assignment and force employment. It involves force coordination/feedback and operation monitoring to determine directive compliance and situation changes.

3.2.6 Support Functions

These functions are employed in support of most of the Principal Functions and, to some degree, are event/scenario independent. They consist of Compu-tational Support, Display/Presentation Support, Communications Support, Data Base Management, Training, and Security. Application program element details are listed in the ACCAT systems description document.

4.0 APPLICATIONS

4.1 Each application is briefly described in the following format.

Application No.
1. Title
2. Operational Function
3. Technology
4. Application Definition
5. Approach
6. Capability Goals/Value to the Fleet
7. Related Applications, other efforts

Some entries might not appear since the listed applications differ greatly in level of detail. In some the "Approach" may be quite obvious while in others

a well thought out approach would be a separate task even though the definition is clear.

Since a number of people contributed applications and used terms familiar to themselves in their descriptions, technologies appear in the applications which were not listed in section 2. Table 2 is a grouping of the technology areas that appear in the applications section relative to section 2, plus miscellaneous, but highly related technologies.

4.2 <u>Application Summaries</u>

PRINCIPAL FUNCTION / RESEARCH APPLICATIONS	ALERTS & NOTIFICATIONS	EVALUATION & THREAT/SIT.	RESOURCE AVAIL PLANNING	CURRENT OPER. PLANNING	EXECUTION	SUPPORT FUNCTIONS
1 MSG PREP AID						COMM
2 OPTIMUM FORCE POSTURE				X		COMPUTE
3 ASSESS ENEMY CAP & INTENT		X				
4 COVER & DECEPTION				X		COMPUTE
5 LOGISTIC SUPPORT RQTS			X			
6 EXPECTED RESOURCE COST				X		
7 ASSESS ENEMY LOGISTICS		X				
8 BATTLE MGT			X	X		
9 SHORTFALL & ALT CORREL			X			
10 OPLAN ADAPTATION				X		
11 QUIET TASK FORCE		X		X		
12 REVISION OF UNDERWAY PROCEDURES				X	X	
13 OTH TARGETING		X		X		
14 CRISIS MANAGEMENT		X		X	X	
15 C&D INFORMATION EXCHANGE		X		X	X	
16 FREQ MGT						COMM
17 FLEET SENSOR COVERAGE				X		COMPUTE
18 HULTEC		X		*		

Table 1. Application vs Functions

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#	PRINCIPAL FUNCTION / RESEARCH APPLICATIONS	ALERTS & NOTIFICATIONS	EVALUATION & THREAT/SIT.	RESOURCE AVAIL PLANNING	CURRENT OPER. PLANNING	EXECUTION	SUPPORT FUNCTIONS
19	THREAT RECOGNITION	X			X		
20	ADAPTIVE DECISION						
21	CONCEPTUAL PROCESSING		X	X	X	X	
22	ADAPTATION OF OPLANS						
23	RADIO CHANNEL ALLOCATION				X	X	COMM
24	WORK AND INFORMATION FLOW MODEL			X	X		
25	AUTOMATED DATA RE-DISTRIBUTION			X	X		
26	AUTOMATED DISTRIBUTION OF TASKS			X	X		
27	MULTILEVEL SECURE SPEECH		X	X	X	X	
28	DATA EDITING TABLET				X	X	
29	OTH WEAPONS PRE-FIRE			X	X		
30	SAILING DIRECTIONS				X		
31	SINGLE SHIP REFUELING	X	X				
32	TARGET CORRELATION & ID	X	X				
33	MISSION PLANNING		X	X	X		
34	WHAT-IF DISPLAY				X	X	
35	SENSOR/WEAPON COVERAGE		X	X			
36	IN-PORT TRAINING				X		

Table 1, cont.

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	PRINCIPAL FUNCTION	ALERTS & NOTIFICATIONS	EVALUATION & THREAT/SIT.	RESOURCE AVAIL PLANNING	CURRENT OPER. PLANNING	EXECUTION	SUPPORT FUNCTIONS
	RESEARCH APPLICATIONS						
37	SEARCH PATHS				X	X	
38	ENVIRONMENTALLY INFLUENCED SAILING DIR.			X	X	X	
39	SENSOR MANAGEMENT TASKING			X	X	X	
40	SENSOR OPTIMIZATION			X	X		COMPUTATION
41	TACTICAL EM UTILIZATION				X		
42	MAN/SYSTEM INFO. COUPLER						DISPLAY SUPPORT
43	FORCE DIRECTION					X	
44	SIMULATION EXERCISE						TRAINING SUPPORT

Table 1, cont.

Artificial Intelligence

Intelligent terminals
Production rules
Heuristic programming
Heuristic search
Adaptive programs

Decision Aids

Real time interactive decision networks
Deductive data management
Adaptive decision aids
Advanced command and control decision aids

Query Systems

High level language
Query language
Natural language
Natural language interface to data management systems
Man/machine interface

Data Base Management

Sensor data management
Underway procedures management
Distributed data bases
Information input processing
Distributed information processing
Large data base management

Miscellaneous Technologies

Networks
Sensor correlation
Digital data transmission
Displays
Computational support
Simulation modelling
Secure voice
Encryption
Character recognition
Navigation
Prediction
Interactive terminal
Optimal searching
Human factors
Computer Science

Table II. Technology Breakdown

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APPLICATION 1

1. **TITLE:** STATUS/READINESS REPORTING MESSAGE PREPARATION AID

2. **TECHNOLOGY:** Intelligent Terminals, Production Rules, Decision Aids

3. **APPLICATION DEFINITION:** Local intelligent terminals with additional storage (tape cartridge or small disk) can serve as aids to the preparation of reporting messages (MOVEREPS, CASREPS, FORSTAT, etc.) thereby reducing the errors in their content. Past efforts have been concerned with the communications portion of the message preparation problem, while the message content causes the bulk of the problems with the Navy command control data bases. This type of aid could assist the report originator to understand each element in the reporting message, and to also store information that could be helpful in filling in the message reports. Additional readiness/status information could be collected on-line from the Operational Readiness Monitor System (ORMS).

4. **APPROACH:**
    a. Initial experiment (a portion of one reporting message) using large host and high level language

    b. Complete experiment (with all message types) on large host with high level language

    c. Translate the Aid system to a RITA type terminal/system and demonstrate it as a stand alone system

    d. Incorporate a tie-in to the ORMS test bed (NAVSEA 6.2 program) and the AFCCT terminal

5. **VALUE TO FLEET:** Many of the data bases which we now have are filled with partially incomplete, erroneous, and untimely data due to the problems associated with preparing the reporting messages at sea. A reduction in the 'source' error rate would increase the Fleet Commander's knowledge of the Fleet's readiness and status greatly (it will also upgrade the value of the shore data bases and associated ADP hardware/software).

APPLICATION 2

1. TITLE: OPTIMUM FORCE POSTURE

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Calculate the optimum posture of own force to
oppose the known or most likely threat. Calculations to include: best placement
of carriers in a single or multi-carrier task force; best placement of AEGIS
platforms, singly or in combination with 3-T missile platforms; against a
multi-dimensional missile threat; best placement and employment of surface
combatants with tactical towed arrays, LAMPS, and various sonars, against the
submarine threat; best placement and employment of patrol aircraft, fixed
wing carrier ASW aircraft, and ASW helicopters in concert with friendly SSN's
and surface ASW forces; and best employment of CAP and EW aircraft in com-
bination with AEGIS and 3-T platforms. Additional considerations include:
EMCON plan; overall surveillance plans and schedules; replenishment schedule;
PIM projections; and own capability as modified by CASREPS, logistic shortages, etc.

4. VALUE TO FLEET: Would give the operational commander the capability to
optimize strategy and tactics on the basis of available information; and to
make timely adjustments in the light of new information. Would partially
satisfy O.R. P-14 of the Navy C^3 Architecture Workbook, dated August 1975.

APPLICATION 3

1. TITLE: ASSESS ENEMY CAPABILITIES/INTENTIONS

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given the estimated composition of an enemy force, assess the capabilities of that force with respect to the mission(s) of own force. Using knowledge of the enemy's strategy and tactics, observed use of sensors, disposition and for nation(s), available logistic support, material readiness, supporting surveillance forces, and possible cooperating combat forces, assess the enemy's intended course of action.

4. VALUE TO FLEET: Would permit the operational commander to make timely assessments of the situation, preparatory to determining the optimum posture of his force. Would indirectly provide partial satisfaction of O.R. P-14 of the Navy C^3 Architecture Workbook, dated August 1975, by facilitating analysis of the threat against which own force posture is to be optimized.

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APPLICATION 4

1. TITLE: COVER AND DECEPTION

2. TECHNOLOGY: Decision Aids, Heuristic Programming, Data Base Management

3. APPLICATION DEFINITION: Given own force mission, and postulated operating constraints, the estimated surveillance and combat capabilities of the opposing force, and environmental conditions, determine the optimum cover and deception plan to be employed by own force.

4. VALUE TO FLEET: Would give the operational commander the ability to make rapid comparative evaluations of alternatives with respect to cover and deception tactics, and to make timely adjustments when required by changes in the perceived situation.

APPLICATION 5

1. TITLE: LOGISTIC SUPPORT REQUIREMENTS

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given a requirement to execute an OPLAN, or to
satisfy an ad hoc operational demand, determine the logistic support required.
This would include not only estimation of requirements for consumables such
as fuel, ammunition, repair parts, and food, but also identification of the
sources of such support. If necessary supplies are not on hand within the
action force, identify which mobile logistics forces have the supplies. Cal-
culate earliest times and best positions for underway replenishment, and their
possible impacts on the intended operation. Determine logistic train require-
ments which would ensue from a prolonged action, and identify ships and supply
bases which would provide the necessary support.

4. VALUE TO FLEET: Would give the operational commander the ability to make
timely decisions regarding logistic factors which might otherwise constrain
his tactical options.

APPLICATION 6

1. TITLE: EXPECTED RESOURCE COST OF A COMBAT ACTION

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given a known friendly force and an estimated enemy force, with: dispositions; stochastic and deterministic capabilities of weapons, sensors, communications, platforms, and logistics; environmental conditions; and availability of re-inforcements; and rules of engagement. Compute the expected costs which would be incurred by each side in terms of: ship and aircraft losses and damage; personnel casualties; fuel and ammunition expenditures; and loss of ability to perform subsequent missions.

4. VALUE TO FLEET: This capability would provide an operational commander with a rapid and accurate assessment of the probable outcome of a planned or potential engagement, and thus would afford a better means of preserving fleet effectiveness by avoiding unintentional participation in combat actions which would impose unacceptable resource costs.

APPLICATION 7

1. TITLE: ASSESS THE ENEMY'S LOGISTIC OPTIONS

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given the logistic support available to the enemy force from both afloat and base sources, the estimated levels of fuel and ammunition on board the enemy force, and estimated rates of consumption, assess the enemy's logistic options with respect to his action radius and ability to carry out postulated plans. Assess the impact of denying the enemy any specified subset of his available logistics options.

4. VALUE TO FLEET: This capability would permit an operational commander to readily assess the enemy's capability in terms of logistic limits, and to assess the cost of interdicting the enemy's supply lines in terms of the probable effect of partial or complete success.

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APPLICATION 8

1. TITLE: BATTLE MANAGEMENT

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given that own force is committed to combat, monitor
and assess all battle events with respect to the current and projected ability of
own force to carry out assigned mission(s). Effects of attacks delivered and
defensive measures employed by both sides would be measured in terms of fuel and
ammunition expenditures, and losses and damage sustained by both sides, to-
gether with resultant changes in the offensive and defensive envelope parameters
of own and opposing forces. Impact assessment would include recommendations as
to reassignment of own force unit missions, diversion of resources to compensate
for losses, modification of engagement range, etc. Defensive/counteractive
resource reallocations considered would recognize, inter alia, the estimated
view that the enemy holds with respect to his missions and target priorities.

Collateral assessment would be in terms of the likelihood of successful
outcome of the engagement, together with an estimate of the latest time at which
a decision to commit additional forces or to disengage could be successfully
implemented.

4. VALUE TO FLEET: Would give the operational commander the ability to make
operational time judgments over the full multi-dimensional spectrum of the
battle management problem, thus enhancing the probability that he will remain
in control of the situation.

APPLICATION 9

1. TITLE: SHORTFALL AND ALTERNATIVE CORRELATION

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Provide correlation capability to make the following
types of comparison to identify shortfalls and alternatives:

    a. Quantities of forces required by an OPLAN - vs - forces currently
        available or projected for a future date.

    b. Force requirements as derived from threat analysis - vs - forces
        actually available or forces required by an OPLAN.

4. VALUE TO FLEET : Would provide the operational commander with the means of
readily assessing force requirements with respect to planned or potential
operations. Would partially satisfy O.R. P-14 of the Navy C^3 Architecture
Workbook, dated August 1975.

APPLICATION 10

1. TITLE: QUICK REACTION ADAPTATION OF OPLANS TO CONFORM TO ACTUAL FORCES
AND DISPOSITIONS

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Given that available forces are different from those
required by a given OPLAN, compute the necessary modifications to the OPLAN in
order to make most effective use of available forces in pursuance of the OPLAN
objectives.

4. VALUE TO FLEET: Would enable operational commanders to rapidly assess the
feasibility of adapting existing OPLANS to available forces, thus enhancing
quick reaction capability in situations where force levels are changing dyna-
mically. Would be particularly valuable during the redirection and reconstitution
phase. This development would partially satisfy O.R. P-14 of the Navy C^3
Architecture Workbook, dated August 1975.

APPLICATION 11

1. TITLE: QUIET TASK FORCE

2. TECHNOLOGY: Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: Using surveillance and intelligence information obtained from systems outside the task force, and from passive systems within the task force, evaluate the threat situation with respect to both detection and attacks, and determine the optimum time to resume active sensor search and to resume external communications.

4. VALUE TO FLEET: Would provide the operational commander with a means of assessing the effectiveness of his EMCON plan, and of determining the time at which resumption of electronic activity would yield information about the enemy which is of significantly greater value than the information which the enemy could gain from electronic intercepts.

APPLICATION 12

1. TITLE: REVISION OF UNDERWAY PROCEDURES FOR SHIPS OPERATING IN CONSORT WITH AIRCRAFT CARRIERS

2. TECHNOLOGY: Sensor Data Management and Underway Procedures Management

3. APPLICATION DEFINITION: During the past few years a number of calamitous collisions and near collisions have occurred between small to medium naval vessels and aircraft carriers. The ordinary rules of the road between vessels presumably have applied (and used by the subordinate vessels), but the tragedies still occurred. It is fact that carriers even when operated by the prescribed regulations are of such size that proper evasive tactics may not be feasible. Further this is particularly true when deploying aircraft. It may be that special tactics should be employed to prevent these tragedies. This task would entail collecting all available data on crashes and near crashes, applicable tactics and rules of the road, and using this data and the ARPA facilities to determine what tactics, maneuvers, use of sensors, computer algorithms or others, should be employed by ships in the presence of carriers.

4. APPROACH:

    a. Initial data

    b. Data analysis

    c. Development of improved tactics

    d. Validation of new tactics with Fleet Personnel

5. VALUE TO FLEET: Accident prevention, collision avoidance.

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APPLICATION 13

1. TITLE: OVER THE HORIZON TARGET COORDINATION

2. TECHNOLOGY: (NELC, ARPA, and Contractors)
    Distributed Data Bases, Networks, Data Transmission, Sensor Correlation

3. APPLICATION DEFINITION: The development of the cruise missile (and any
other "Over the Horizon") strike capability for ship platforms requires an equal
capability in detection and target assignment. Efforts are being made to pro-
vide some sort of sensor for the ship without great success. One possibility
is for data bases such as OSIS and the main floor WWMCCS systems which collect
"enemy" and "friendly" position information from a variety of sensors to supply
the data to the ship. The study effort proposed here is to determine the tech-
niques required to give the ships rapid shore data base query capability from
any or all of the data bases with the required information.

4. APPROACH:

    a. Collect data from ongoing programs on requirements

    b. Collect data on information content of presently planned data bases

    c. Analyze and propose alternative methods to provide the ship/shore data
        transmission capability

5. VALUE TO FLEET: The development of the cruise missile is underway. The
threat is clearly defined. The sensor detection capability must be developed
to make use of the missile to counteract the threat.

APPLICATION 14

1. <u>TITLE</u>: CRISIS MANAGEMENT, STATUS ACCOUNTING

2. <u>TECHNOLOGY</u>: Decision Aids, Intelligent Terminals (NELC, SRI, RAND (RITA), Perceptronics)

3. <u>APPLICATION DEFINITION</u>: During a time of crisis many actions are initiated and many more results/inputs are generated. These actions must in turn be monitored along with external inputs to keep up with the status of the situation (crisis). One of the key issues in a crisis situation is the generation of new events which can impact the initial plan and result in modified actions.

..   A solution to the crisis management-status accounting problems is to provide a decision aiding/planning tool in an intelligent terminal environment. Plans for different crisis situations can be stored on a magnetic tape cassette or equivalent and initialized for each situation. Parameterized inputs can be made for each situation to establish variables together with exception data. As the crisis situation progresses the output of the aid device will be notification of action items which are scheduled and the dynamic 'picture' of the crisis as modified by new events. Manual or automatic inputs could be used to maintain the status situation. The SAR (Search and Rescue) demonstrations are representative examples of this problem domain. Both network and stand alone solutions are applicable.

4. <u>APPROACH</u>:

   a. First experiment (subset)

   b. Second phase (complete subset showing all major functions)

   c. Full scale capability (unclas)

   d. Operational data experiments

5. <u>VALUE TO FLEET</u>: Crisis management is a universal problem which can be focused at a single ship level or on major portion of the world. A goal of this research would be to identify a single tool or family of tools which could fit most situations.

APPLICATION 15

1. TITLE: SOFTWARE LANGUAGE AND DATA TRANSFER PROTOCAL FOR SHIP/SHORE COVER &
DECEPTION (C&D) INFORMATION EXCHANGE.

2. TECHNOLOGY:
Hi Level Language, Distributed Data Bases, and Digital Data Transmission

3. APPLICATION DEFINITION: Problem - One of the major command control defi-
ciencies in the Fleet today is the inability to provide specific C&D data
(which resides in one or more shore based computer data banks) to Fleet elements
which could use the data in a timely manner.

The data transfer between shore sites is being investigated and resolved
by such programs as ARPA, OSIS, WWMCCS, AUTODIN II, and others. To resolve
the shore to ship data base query problem, a different set of criteria must be
developed due to the nature of the ship based operators, and the NTDS and other
ship data systems. It is likely that the ship operators will not have the
technical computer operator oriented background of the counterparts in the
shore establishments; therefore a simple hi-level language should be developed
to allow him to make specific queries from the shore data bases. In addition,
the terminal for shipboard use and the message transfer protocal from the ship
must be developed.

This task is intended to provide the initial analysis and tradeoffs necessary
to undertake the required development.

4. VALUE TO FLEET: Resolution of a critical C&D problem.

APPLICATION 16

1. <u>TITLE</u>: FREQUENCY MANAGEMENT

2. <u>TECHNOLOGY</u>: Distributed Data Bases, Networks

3. <u>APPLICATION DEFINITION</u>: Multiple data bases (ships equipment, sensor limita-
tions, weather, weapons systems, etc.) will be accessed to provide a set of
task force operating frequencies which will minimize mutual inference. Since
frequency couplers will overload if required to carry a particular frequency
mix there must be an automated test to insure against this. Often frequency
assignments are made without knowledge of what couplers are on board ship.
The ownsbips equipment data base should contain this information for use by
the frequency management program.

4. <u>VALUE TO THE FLEET</u>: This capability will provide the task force with an
organized method of assigning communications frequencies, sensor frequencies
and weapon system frequencies to minimize interference. The present method is
computer assisted which can handle a small number of missile frequencies. There
is no automatic checking for possible coupler damage. Having this protection
will reduce down time due to equipment failure.

APPLICATION 17

1. TITLE: FLEET SENSOR COVERAGE

2. TECHNOLOGY: Distributed Data Bases, Displays, Decision Aids

3. APPLICATION DEFINITION: Since the detection coverage of shipboard sensors
is affected by the environment, a task force commander must continually be
monitoring both weather conditions and positions of ships in company force to
assure adequate sensor coverage of the task force. If a sensor asset goes down
or the weather changes, then the formation may be changed to compensate. At
present, colored plastic overlays are used as an aid in determining sensor
coverage. What is needed is advanced display presentation of radar coverage
profiles (path loss vs range) and sonar profiles (e.g., convergence zones) to
enable a force commander to properly dispose his task force for optimum
coverage.

4. VALUE TO FLEET: Manual plotting of radar profiles would be eliminated with
this system. Since the plotting system is mathematically based, a message
could be sent when coverage degradation occurs, due to environmental changes
or equipment failure.

APPLICATION 18

1. TITLE: HULL-TO-EMITTER CORRELATION

2. OPERATIONAL FUNCTION: Evaluation and Threat Situation

3. TECHNOLOGY: Query Lanugage, Computation Support, Decision Aids

4. APPLICATION DEFINITION: The identification of own-force platforms can be enhanced by examining EM emanations, traffic activity, and spectrum utilization characteristics. The denial of this identification capability to hostile forces first requires assessment of possible platform configuration and then employ- ment of appropriate counter-measures. This research application is concerned with providing assistance in estimating probability of identification for given input parameters and alternative employment of EM (electromagnetic) assets and their impact on given mission conditions.

5. APPROACH:

   a. Construct data base from given platform characteristic elements.

   b. Develop computational routines for assessing uniqueness of platforms based on the identification parameters.

   c. Develop query language and decision aids to support best selection of platforms emissions as a function of time, position and environment. Alternative platform (or platforms) configurations will be presented in terms of impact on mission objectives.

APPLICATION 19

1. TITLE· THREAT RECOGNITION

2. TECHNOLOGY: Natural Language, Distributed Data Bases, Decision Aid

3. APPLICATION DEFINITION: The following is a classification of three types of naval threat recognition problems (at the task force thru fleet level of command). They have been differentiated on the basis of technology needed to support the effort.

Level 1. Proximity Threats

These can be considered fairly simple queries to a status of forces data base. They are generally queries of the form: "if there are any --- within --- nautical miles, sound an alert." Examples: (assume the appropriate context has been given)

Immediate Threats

    a. Charlie class submarine with initial detection < 30 miles

    b. Echo class sub with initial detection < 250 miles

*   c. Bear aircraft with i.d. < 250 miles

    d. Any submarine within torpedo range (about 5 miles)

    e. Any SSBN with i.d. < missile range (about 1500 miles for Yankee)

*   f. Any surface missile boat < 30 miles

Secondary Threats

    g. If Charlie class sub has i.d. < 30 and course, speed vector will place it < 30 miles, then it is a "potential threat". System should keep track of it and up/down grade it as appropriate.

    h. Same for echo class and 250 miles

Most Important Threats

*   i. Low flyer closing and < 50 miles

*   j. Cruise missile inbound

Surface Threats

    k. DDG < 30 miles,

    l. CLG < 250 miles,

    m. CA < 10 miles, etc.

*Means this information does not exist in unclassified data base.

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Level 2. Situational Threats

These are threats represented by particular situations which should be recognizable to a system, where the discovery of the situations is left to the experienced naval personnel. The notion here is that a situation can be described, and if the state of the world is such that the situation exists, that is an immediate threat. But systems should also have the capability for recognizing partial situations, and note the potential threats and their level.

An example of a "situation" as used here is the following: A Swerdlov class ship normally is used as a forward spotter for an Echo class submarine. The tracking range of a Swerdlov is 100 miles, while the communication range from a Swerdlov to a sub is 300 miles. Thus, if a Swerdlov is within 100 miles of friendly forces, and is tracking them, and an E class sub is within 300 miles of the Swerdlov, then a danger situation exists. (The attack scenario is that the sub would move into missile range (250 miles) of the friendlies, then fire. This means that if the sub is already within that range, the danger is that much greater.)

Note that the notion of "tracking" is not an observable piece of information which is in the data base. It can be inferred, perhaps, that if the Swerdlov stays on the same course and bearing from the friendlies, it is tracking them. And perhaps if it is ever within tracking range of them it may be tracking for that period of time. And there may be other inference rules to guide the determination of probability of existence of tracking.

Note also that there may be more than one submarine which is communicating with the Swerdlov, each of which is a potential threat. Or there may be some forward spotter substituting for the Swerdlov this particular time.

Level 3. "Creative" Threat Recognition

This is a category built simply to contain all those activities not covered in the other two. The discovery of "threat situations" as used in Level 2 is one area. Noticing abnormal patterns of behaviour may be another example.

4. <u>VALUE TO FLEET</u>: Would fill a Situation Assessment need in the NCCS Architecture.

APPLICATION 20

1. TITLE: ADAPTIVE DECISIONS IN TASK FORCE MULTITHREAT MISSILE DEFENSE

2. TECHNOLOGY: Problem Solving Methodology including Heuristic Search, Adaptive Programs, Real Time Interactive Decision Networks

3. APPLICATION DEFINITION: The decision making functions used to counter task force missile threats are characterized by a complex, time constrained process of data assimilation, data evaluation, and deployment of assets such as sensors, EW, ECM, ships, aircraft and weapons. Operational effectiveness depends heavily on decision making performance. Problem solving and heuristic search techniques allow the structuring and evaluation in real time, of possible alternatives while considering probable consequences arising from future counter-measures by looking ahead a few steps in time. The values placed on information and decision consequences are taken from human experience and judgment. Decision recommendations (along with supporting evidence) are available to the Commander based upon a comparison of a great number of possible courses of action.

4. APPROACH:

   a. Demonstration of counter missile threat decision functions using one type of ASCM attack under constrained resources (PDP-10 high level language).

   b. Complete system function demonstration including a realistic decision environment, real-time interaction, and events update capability.

   c. Full scale system implementation on a PDP-11 (UNIX operating system) with a capability for real time environment update as well as expanded interactive capabilities for evaluation function adjustment. Demonstration with simulated data.

   d. Demonstration and experimental evaluation with operational data.

5. VALUE TO THE FLEET:

   a. Increased operational effectiveness of ASCM defense through generation, selection, and recommendation of high-probability threat countermeasures.

   b. Improved ability to maintain optimal defense strategies in varying environments by adapting to changes.

   c. Reduced potential threat effectiveness through reduction of decision time allowing earlier threat engagements before reaching WRL.

APPLICATION 21

1. TITLE: CONCEPTUAL PROCESSING

2. TECHNOLOGY: Natural-Language Interface to Data Management Systems

3. APPLICATION DEFINITION: Information retrieval is a basic need in most of
the basic command and control processes: situation assessment, decision and
direction, and report generation. In addition to having an adequate data
management facility, a most important need is the user interface. Natural
language seems to be amost attractive choice for user communication, but most
developments of natural language processors were large, inefficient, and imprac-
tical. Conceptual Processing is a newly developed technology at SDC which is
based on a nonconventional approach to Natural Language Processing. The
approach suggests that a Natural Language Interface (NLI) to a given application
system should emphasize the modeling (conceptualization) of structures and
functions of the application, rather than the linguistic properties of Natural
Language. Thus, the NLI will be required to deal only with the subset of English
that the application program can handle. In the area of data base retrieval,
the NLI has to be powerful enough to process English queries against a data base
only, avoiding the complexity of "understanding" irrelevant forms of English.
Furthermore, because the NLI relies on explicit modeling of structures and functions
of the underlying data management system. It can perform the "understanding"
process in a more concise and efficient manner, since it does not need to
search for possible English constructs that are not used in the application.

   A prototype version of the conceptual processor is currently implemented
in LISP. Several data bases were experimented with including Jane's ship data
base. The program is small (about 15K bytes), efficient (less than a second
for an average query), tolerant of non-perfect (ungrammatical) input queries,
and adaptable to any data management system that supports a query language.

4. APPROACH: We propose to incorporate the NLI in the core of the testbed on
the PDP-10 (or PDP-11 if so desired), using an INTERLISP or LISP versions
existing on these machines. This process will take place in three phases with
the ultimate goal of being able to process English queries directed to the
testbed data base described in NELC Technical Note J732.

Phase 1: In this phase, an appropriate subset of the NELC data base (in
Technical Note J732) will be "conceptualized" and semantically described on the
existing NLI prototype. This phase will culminate with a demonstration on our
prototype in which English queries to the data base will be accepted and an
equivalent query in the data management query language will be produced (the
current version produces TDMS-like queries). This phase will require 3-4 man-
months of effort.

Phase 2: The Installation of the prototype on a PDP-10 (or PDP-11) at NELC.
Since there are several differences between versions of LISP or INTERLISP,
some changes will be required to the prototype version before installation.
The effort for this installation is estimated at 1-2 man-months. If by this
time a specific data management system has been identified for the testbed,
then a "translator" to generate queries in this DMS query language will be
implemented. Since the translator is a separate module from the language
analizer, its cost is only incremental. This task is estimated at about 4-5
man-months.

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Phase 3: In this phase, the NLI will be interfaced with the DMS for the purpose of retrieving actual data. The complete description of the data base for the language analyzer will be produced, and mechanisms required to tune the system for the specific needs of users of the data base will be added. A rough estimate of this phase effort is 4-7 man-months.

5. VALUE TO FLEET: Permitting command and control personnel in different levels and capacities to extract data base information through the use of natural language. The potential value is in cost reduction in personnel training, in the elimination of the need to use rigid formats in many applications, and in the availability of the system to the casual computer-naive user.

APPLICATION 22

1. TITLE: ADAPTATION OF OPLANS TO ACTUAL FORCE DISPOSITION

2. TECHNOLOGY: Deductive Data Management, Decision Aids

3. APPLICATION DEFINITION: Derive a modification that will give an OPLAN that will make most effective use of available forces in obtaining OPLAN objectives. Utilize deductive inference to discover the consequences of change in available forces on achievement of OPLAN objectives. Aid situation assessment and decision making processes by selective presentation of evidence for (and against) various alternatives.

Move NELC unclassified data base into SDC's Deductive Data Management prototype and construct general statements (premises) characterizing a simulated OPLAN. Utilize ."What if" queries to explore consequences of variations in available forces on attainment of various OPLAN objectives. Iterative refinement and expansion of the file of general statements to represent increasingly more realistic OPLAN sitautions.

4. APPROACH:
   a. First Phase (small scale experiments with NELC data base subset) - 3 man-months.

   b. Second Phase (demonstrate all major functions) - 12 to 18 man-months.

   c. Full scale capability (with connection to DATACOMPUTER data base and Natural Language Processor) - 18 man-months.

   d. Operational experiments - ?

5. VALUE TO FLEET: (Similar to application 10 in ACCAT Note #1). Would provide commanders with the ability to rapidly assess the feasibility and likely consequences of adapting existing OPLANs to forces at hand. Would enhance quick reaction capability in dynamically changing environments and would provide information of use in refining and elaborating OPLANs.

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APPLICATION 23

1. TITLE: RADIO CHANNEL ALLOCATION

2. TECHNOLOGY: Heuristic Programming, Advanced Command and Control Decision Aids

3. APPLICATION DEFINITION: The Navy is currently experiencing radio channel interference. The cause of this interference is not a lack of available channels, but a lack of efficient allocation of the available channels. It is desirable that the Navy have an automated channel allocation program that could use the Navy data base to assign channels to minimize channel interference. The Navy allocation problem can be modeled as a graph coloring problem by imagining radio broadcast locations as the verticles of a graph, with a common edge in the graph if the two locations would interfere with each other if they were to use the same channel. Then a channel allocation is a graph coloring if no two broadcast locations are assigned channels so that they interfere. Recent findings in graph theory pertaining to graph colorings would be incorporated into a computer program that would assess the Navy data base to obtain ship locations, and allocate radio channels that minimize channel interference.

4. APPROACH: 4 man-months to have an initial version operational, an additional 4 man-months to test and compare various other heuristic algorithms for optimal performance.

4. VALUE TO THE FLEET: The proposed program would provide the Navy with a capability of rapidly changing the allocation of radio channels during wartime operations thus reducing the interference produced by enemy electronic counter-measures while allowing the fleet to maintain effective communications between ships.

APPLICATION 24

1. TITLE: WORK AND INFORMATION FLOW SIMULATION MODEL

2. TECHNOLOGY: Adaptive Decision Aids, Simulation Modelling

3. APPLICATION DEFINITION: Simulate the effect of fleet readiness changes in the staffing, use of automated equipment, and priority assignment during the routine and wartime operation of Command and Control processes. The simulation model written in SIMULA would be interactive and easy for an uninitiated user to understand and use. It would be general enough to allow the modelling of many diverse Command and Control processes. The model would include the capability to allow the user to interactively make structural changes in his model during simulation run time and to interactively save the state of the model for use as a starting point for future simulations. The model could be used to simulate many Command and Control environments, including the following:

a. The flow of message traffic through a global communications network.

b. The flow of messages through a single station of a communications network.

c. The flow of supplies in a logistics network.

d. The flow of ships through a shipyard.

e. The flow of paper in a command center.

SDC has constructed and installed such a system for the state of California's Fingerprint identification activity.

4. APPROACH: 4 man-months to complete an initial version of the model and 8 man-months to provide the final version including all proposed features.

5. VALUE TO THE FLEET: The model would provide a Commander with a powerful tool to assist him in the decision process. A Commander could evaluate the effect on operations of replacing manual processes with automatic or semi-automatic processes or of altering the priority assignments. During wartime operations, the effect of damage could be measured and damage control strategies studied quickly. Within the ACCAT application program itself, the model will be a valuable aid in evaluating the effect on work and information flow of various proposed operational uses of ACCAT application programs.

APPLICATION 25

1. TITLE: AUTOMATIC DATA RE-DISTRIBUTOR FOR DISTRIBUTED PROCESSING SYSTEMS

2. TECHNOLOGY: Distributed Data Bases, Information Input Processing

3. APPLICATION DEFINITION: Where users require rapid interactive response from a data base management system on a network of distributed processors, the optimal data organization is the construction of local, single processor data base subsets of active data and the maintenance of an index of entry keys of other data base subsets to be used for global queries. By the relatively simple expedient of logging and flagging all data base communications between processors we can determine the selection of data needed at each processor. There are two variations for creating data base subsets, different data base structural definitions and same definitions with different entries. The largest unit of data per index retrieval is a single entry (record) and at the same time the smallest unit of data on which a complete qualification can be made is an entry; thus we must move an entire entry when migrating data. When a request for data is sent to another processor, the reply is intercepted and returned as both a reply to the user and a temporary update of the entry to the local data base subset with source, time, and status flags. The original entry is flagged also. Then the next request by the user will be processed locally. There are a variety of requests which will not trigger data movement. A request for all ships names will not move all ships data. Periodically an entry status list will be sent among all processors and the original entries will be deleted and temporary entries will become permanent. While there are a number of other activities to handle, this method can be implemented by adding a small, simple monitoring program to the data base management system together with the flag items needed for control. Data flow will be kept at a minimum.

4. VALUE TO THE FLEET: While test bed data bases will be few and readily maintained by hand in the beginning, their number, size, complexity and distribution will increase rapidly as they become more usable. The automatic re-distribution will be a requirement, particularly for following ships and crews from port to port.

APPLICATION 26

1. <u>TITLE</u>: AUTOMATED DISTRIBUTION OF TASKS IN A DISTRIBUTED PROCESSOR ENVIRONMENT

2. <u>TECHNOLOGY</u>: Distributed Information Processing

3. <u>APPLICATION DEFINITION</u>: SDC has developed a program verifier to analyze the source code and deduce premises for proving the correctness of program automatically. As a side effect of this analysis, those items shared by several routines or by external programs are noted. The format of all items input and output are also noted. SDC has developed a distributed processor language with special features for both keeping the status of dependent jobs running on separate processors and for synchronizing the sharing of data between jobs. The sharing of data and control information in a central processor isaccomplished by parameter passing in subroutine calls, by I/O to work files, or by accessing a common area in memory. To perform the same data sharing in a multiple processor environment the data is sent by communications channel in response to requests for data over the same channel. I/O sharing presents no more problems in distributed processing than in central processing with access deadlocks, the principal issue, being solved by using a priority scheme. Data Base access is a well solved problem and can most easily be provided by assigning one processor to manage data bases and service data base requests from the other processor jobs.

The method we will establish by combining known solutions with new developments will follow these steps:

a. Scan the source code of all programs of a system we wish to move from a central processor to a distributed processor.

b. Note all program references to shared data and shared I/O.

c. Substitute communication request/reply subroutines for shared data access code.

d. Allocate separate routines to processors and establish synchronization control procedures to run the distributed processor system.

This method can be re-applied as often as necessary to reflect changes in the distributed processing environment of the programming system.

4. <u>VALUE TO THE FLEET</u>: The test bed center plans to use distributed processing techniques on many programs which were designed for centralized processing. We believe that this change from centralized to distributed processing will be expensive and time consuming without the method described here.

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APPLICATION 27

1. __TITLE__: MULTILEVEL SECURE SPEECH

2. __TECHNOLOGY__: Secure Voice, Encryption, Secure Kernel

3. __APPLICATION DEFINITION__: ARPA has had an on going series of projects to develop a mechanism for economically transmitting speech over packet switched networks. Such transmission has been demonstrated both at Lincoln Labs and at ISI with different, but compatible, systems. Both systems employ combinations of general purpose and special purpose computers to compress the bandwidth required and to manage the interface to the ARPA net. At least the ISI system is capable of processing simultaneous conversations. In a secure system it is necessary to assure that there is no mechanism within the speech processor that allows a user to eavesdrop on other conversations.

Two measures are required to assure that conversations can not be monitored or mixed in the communications network or the general purpose computers in the speech processors. These measures provide unique encryption of individual speech streams and assure separation of speech streams wherever speech must be represented in clear text form. Ultimately the program provides for handling separate voice streams at different security levels.

ENCRYPTION: This effort is an experiment in end-to-end voice privacy based upon new advances in communication security protocols and the NBS data encryption algorithm. The approach would use an SDC product called a network cryptographic device (NCD), adapted to interface between the ARPANET IMP and PDP 11 speech processors, in order to provide privacy between speech streams. The NCDs provide separation between individual speech streams from the output interface of the source host to the input of the destination host (i.e. End-to-End encryption). Individual conversations are encrypted by unique, dynamically changed keys so that misrouted packets can not be decrypted.

Note that the NCD provides a different level of privacy than the PLIs provide. PLIs are dedicated to providing communications between a specific pair of hosts. NCDs can communicate with several hosts. PLIs encrypt all packets with the same key, providing no stream separations. NCDs use dynamically changed keys.

KERNALIZATION: This effort is an experiment to demonstrate the guaranteed separation of conversations within the speech processor. Security sensitive portions of a general purpose operating system can be collected into a module called a security kernel. A mathematical proof can be constructed to show that the security kernal performs its specified functions correctly and observes security criteria. The purpose of the security kernel in the speech processor is to guarantee that no process whose functions have not been mathematically verified can handle more than one clear text speech stream, or make unauthorized copies of the stream. Thus, separation of independent streams can be assured. At least one proven security kernel exists for the PDP 11/45. The kernalization task involves interfacing the operating system used by the speech processor to the kernel.

4. __APPROACH AND ESTIMATED COST__: ENCRYPTION: 18 man-months. A demonstration utilizing two network sites can occur after four elapsed months. The demo will show the tramsmission of separately encrypted streams of text. Encryption of speech streams will be demonstrated later. The man month estimate includes

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the equivalent cost of the use of two NCDs for 1 year.

KERNALIZATION: Feasibility Study -- 5 man-months. At the end of the feasibility study a report will be delivered covering the feasibility of kernalizing one of the speech processor operating systems, and detail time and cost estimates for completing the kernalization task.

Specification, implementation and test -- 2 1/2 man-years (scoping estimate only). Some of the labor in this period will be subcontracted to the contractor developing the speech compressor. This aspect will be clarified in the feasibility study.

Other Direct Costs -- PDP 11/45 computer time 1/2 prime shift during implementation and test.

5. <u>VALUE TO FLEET:</u> Provides a demonstration that individuals with access to a speech processor can carry on private conversations. This protects against both overt penetration attempts and browsing. Secure and private speech can be used in conjunction with mixed media conferencing or by itself. The possibilities in a tactical situation are obvious.

APPLICATION 28

1. <u>TITLE</u>: DATA TABLET INPUT FOR EDITING AND MESSAGE PROCESSING

2. <u>TECHNOLOGY</u>: Intelligent Terminals, Character Recognition, Information Input Processing

3. <u>APPLICATION DEFINITION</u>: Rapid and accurate message and text creation, editing, formatting, and other manipulations require methods and techniques that are easily learned, used, and properly human engineered. In a Command and Control environment, where stress can become exceedingly high, errors and the resultant delays (or worse) can be costly. Most keyboard oriented text processing systems (editors and formatters) require a considerable amount of skill and knowledge by the user to take advantage of their full power. To change, delete, or add a word to an existing text requires a considerable number of keystrokes, many of which are concerned with locating the line and position of the word and supplying sufficient context so that the command is unambiguous. The addition of a data tablet, display, and software to an intelligent terminal would permit a user to perform such functions rapidly, accurately, and "naturally" by permitting direct action to be taken on the item to be modified.

SDC has had extensive experience with data tablets, their integration into an interactive environment, and has developed character recognition techniques that are directly applicable to the development of a graphic/data tablet operated text processing system.

To provide a fully comprehensive user interface for an intelligent terminal implies the additional function of recognizing connected writing (cursive script) in addition to recognizing individual symbols and letters. To date, the capability to do so has not been brought to an operational level and requires additional research to do so. We believe that the existing SDC developed character recognition technique can be extended to provide this function.

4. <u>APPROACH</u>: Phase 1, integrate data tablet and display to a PDP 11 and convert character recognizer for demonstration and evaluation - 12 man-months (3 people for 4 months). Phase 2, interface character recognizer to text editing, formatting and message system - 12 man-months (conditional on the difficulty of adapting existing editor, etc. to operate via graphic input). Phase 3, development and demonstration of cursive script recognition - 24 man-months (can be done in parallel with Phase 2).

5. <u>VALUE TO FLEET</u>: Increased efficiency and accuracy of those responsible for creating, manipulating and transmitting messages and other text material in a Command and Control environment can improve overall function as well as avoid the potential penalty associated with errors and delays. Ease of use of such a system minimizes training requirements and the probability of error under stressful conditions.

APPLICATION 29

1. TITLE: OVER-THE-HORIZON WEAPONS PRE-FIRE DECISIONS

2. TECHNOLOGY: Large data bases, Decision Aids, Correlation

3. APPLICATION DEFINITION: Tactical commanders possess weapons which have a range greater than present day shipboard sensors. To effectively use these weapons the OTC must have OTH targeting information. This OTH information is generally not continuously available to the OTC nor under his total control (he may have dedicated control of this OTH information source for a certain fraction of an hour). The OTC needs a planning and decision aid which takes into account the ship positions in the target area (both hostiles and neutrals), when his OTH sensors are available to him, possible and/or probable enemy/neutral ship movements, best estimate of the enemy's capability to fire his OTH weapons, etc. Based on this information the OTC could, for example, set a course which would minimize the capability of the enemy to target him while putting his own force in an optimal targeting position when the OTH targeting asset is next available.

4. VALUE TO FLEET: The fleet commander now has limited means to do near term planning involving correlation of OTH targets, probable COA and the ability to compute surveillance satellite revisit times (both ours and theirs). This pre-fire planning is necessary to gain the best possible targeting information while denying the same to the enemy.

APPLICATION 30

1. TITLE: SAILING DIRECTIONS COMPUTATION

2. TECHNOLOGY: Large Data Base Management, Navigation, Displays

3. APPLICATION DEFINITION: Given any two, ocean or littoral positions on the globe this program would compute sailing courses based on sailing directions for mariners published by either the U. S. Defense Mapping Agency Hydrographic Center or the U. S. Naval Oceanographic Office, and standard Navigation policy.

4. VALUE TO THE FLEET: Results of this program would enable task force commanders to have pre-plotted sailing courses presented to them for their evaluation. Results of this program could be used in surveillance work in which one must estimate the intended sailing courses of ships of interest. This program could be called on by the "Single Ship Refueling" program to give more accurate sailing times and probable courses.

APPLICATION 31

1. <u>TITLE</u>: SINGLE SHIP REFUELING PROBLEM

2. <u>TECHNOLOGY</u>: L·ge Data Base Management, Navigation, AI

3. <u>APPLICATION DEFINITION</u>: Surveillance reports for a soviet or soviet block ship have stopped coming in. Based on best estimates of on-board fuel supplies and last reported position course and speed, where would the ship be most likely to refuel? Data bases would have to be access to determine refueling ports and locations of soviet block orders. Once these locations have been determined probable sailing course and ETA could be computed.

4. <u>VALUE TO FLEET</u>: Would give the operational commander the capability to optimize strategy and actions on the basis of likely enemy ship movements.

APPLICATION 32

1. TITLE: TARGET CORRELATION AND IDENTIFICATION

2. TECHNOLOGY: Intelligent Terminals, Production Rules, Decision Aids, Distri-
buted Data Bases, Digital Data Transmission

3. APPLICATION DEFINITION: The at-sea forces have the sensors and will have the
computer capability to perform track correlation of targets within the sensor
range of their forces. This correlation is based primarily on state vector
information (position and velocity). The information received, though, often
contains identification information which will be beyond the capability of the
at-sea forces to process locally. This data could be processed against the
shore data bases to aid in the identification of contacts.

4. VALUE TO FLEET: By using the shore establishments' extensive data bases
of enemy platform parameters and knowledge of the general location of ocean
contacts, the identification of targets of interest to the at-sea commander
may be augmented, giving the at-sea commander a better picture of his environment
which can help him perform his many missions more effectively.

APPLICATION 33

1. <u>TITLE</u>: MISSION PLANNING

2. <u>TECHNOLOGY</u>: Production Rules, Decision Aids, Distributed Data Bases

3   <u>APPLICATION DEFINITION</u>: One of the major responsibilities of the at-sea commander is mission planning. Planning can require extensive amounts of information, e.g., descriptions of port facilities, airports, local governments, weather, enemy and own resources, etc. There is too much information for it all to be stored and used efficiently at sea. Data bases distributed ashore could be queried to obtain information required for making decisions. Production rules and other decision aids could be used to suggest weapons mixes and tactics.

4. <u>VALUE TO FLEET</u>: More information useful in mission planning would be efficiently available to the at-sea commander and decision aids would help in making more effective and timely plans and decisions. Also inherent in this approach is an augmented capability in distributing the plans and decisions.

APPLICATION 34

1. TITLE: WHAT-IF DISPLAY

2. TECHNOLOGY: Prediction, Man-Machine Interface, Decision Aids

3. APPLICATION DEFINITION: A display presents a graphic picture (which can be formed using alphanumeric characters) of own-force and detected hostile platforms. The operator can enter conditions and assumptions, and ask questions such as: "if all platforms maintain present speed and course, where will they be in 15 minutes?" The answer will be displayed. Time speedup can be used to present a graphic presentation of the activity which would result if the entered conditions held. The process can be reversed to determine what the history has been if the assumptions are correct. The operator may enter turns, criteria under which own or hostile platforms will change course or speed, or requirements that platforms avoid certain areas or approaching each other too closely.

4. VALUE TO FLEET: This would provide a training aid, to be used before entering a combat area with canned scenarios and guidance of trainees. It would be a planning aid, to be used both before combat and also during combat where changes in previous plans were needed. It is a decision aid, showing a commander the likely effect of his decisions. It is a measurement tool, showing how far and how fast a platform can move before reaching an area of effectiveness or hazard. It can be used for exercises and for gaming (players for each side entering their conditions for movement and their decisions as the game progresses). The program and display can be extended to cover other characteristics beside position.

APPLICATION 35

1. <u>TITLE</u>: SENSOR AND WEAPON COVERAGE

2. <u>TECHNOLOGY</u>: Decision Aids, Interactive Terminal

3. <u>APPLICATION DEFINITION</u>: Own-force data base is accessed to determine status, characteristics and parameters of sensors and weapons on each own force platform. Hostile-force data base is accessed to obtain similar information on hostile assets. Operator enters request for display, indicating whether surveillance, weaponry or other capability is of interest, and the constraints involved. The position of each platform is displayed, together with boundaries showing coverage of weapons, sensors or other capability as desired - such as surveillance capabilities against medium altitude air targets, or 50% destruction capabilities of antisubmarine weapons against deep subsurface targets. This type of aid enables commander to see whether he can expect to monitor passage of unfriendly platforms, whether he will be able to effect their passage, whether they can observe or attack his force or all or some of its elements, and what changes in force configuration are desirable. The operator is allowed to place conditions into the presentation (what if sensor number five on platform six loses 10% power, or what if enemy has twice the range in weapon type four as that reported by intelligence sources).

4. <u>ESTIMATED COST</u>:

   a. Definition of algorithms and preparation of program

   b. Initial demonstration using standard scenario

   c. Eventual attempt to use actual exercise data

5. <u>VALUE TO FLEET</u>: A fleet or force level commander wants to know what he knows and what is uncertain. A display which shows not only the targets which have been detected and tracked but also the area beyond which his sensors lack coverage provides him with a feel for the kind of surprises an enemy may present. Display of hostile coverage capability allows deceptive tactics to be more effectively orchestrated.

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APPLICATION 36

1. TITLE: IN-PORT TRAINING AND SHIP OPERATIONAL PROGRAM (SOP) EXERCISER

2. TECHNOLOGY: Digital generation and realistic, real-time simulation of maneuvering targets, Ownship (O/S) motion, and digital outputs of shipboard sensors, such as Radars, Sonars, IFF (Interrogation Friend or Foe), ESM (Electronic Support-Measures), ECM (Electronic Counter-Measures), and Navigation.

3. APPLICATION DEFINITION: To provide realistic and real-time multi-threat and multi-sensor stimuli and digital input data for the land-based or in-port exercise of NTDS Ship Operational Programs (SOP) and for the pierside training of the ships' CIC operators. A simulated, coordinated, dynamic scenario would require real-time generation of the following digital parameters:

   a. Maneuvering Targets:

      (1) Airborne
      (2) Surface
      (3) Subsurface

   b. Ownship (O/S) Motion:

      (1) O/S Position and Velocity
      (2) O/S Gyro output (Heading, Pitch, Roll)

   c. Simulated Digital Outputs of O/S Sensors, Such As:

      (1) Radars (3-Dimensional, 2-Dimensional, Gun-Control, Missile-Control)
      (2) Sonars
      (3) IFF Equipment
      (4) ESM and ECM Equipment
      (5) Navigation Receivers (Manual inputs by the Navigator, OMEGA, Satellite Navigation (Doppler), NAVSTAR/GPS (Global Positioning System)).

This SOP and Training Exerciser will check out the following CIC operator functions:
   - Detection
   - Tracking
   - Correlation
   - Identification
   - Classification
   - Threat Evaluation
   - Weapon Assignment
   - Aircraft and Ship Control
   - Situation and Status Reporting
   - Data Extraction (on-line, during the exercise)
   - Data Reduction (off-line, after the exercise)

5. VALUE TO FLEET:

   a. Approximates Fleet Exercises: Fleet Exercises are expensive and non-repeatable. Moreover, ships at sea have a specific role and often cannot deviate from that role to perform a variety of training exercises.

b. Provides a realistic test of the SOP: Only the sensors and inputs are simulated, the actual configurations of CIC operations of men, computers, and displays are real.

c. Provides realistic training for CIC Operators: Rapid turnover of Navy personnel requires a continued training effort, whenever possible. This pier-side training would be realistic and cost-effective.

d. May augment or replace existing simulation systems, such as the JITF (Joint Interface Test Force) Simulation System, which performs similar pierside simulation and exercise functions. The JITF Simulation System connects one or more ships with the central simulation generation facility, via voice-grade telephone lines, to provide multiunit on-board tactics training.

APPLICATION 37

1. TITLE: SEARCH PATHS

2. TECHNOLOGY: Theory of Optimal Search, Production Rules, Intelligent
    Terminals, Distributed Data Bases

3. APPLICATION DEFINITION: Different searches require different search strate-
gies and paths depending on the goals and constraints of the search. For ex-
ample, a SAR operation could have time as a very critical constraint but have
limited resources with which to perform the search. However, in a search for a
lost nuclear device time may not be as critical as maximizing the probability
of finding it, with a minimum expenditure of resources. This would be the
case if the lost device landed in a third world country that didn't relish the
idea of having the Marines land to help find the device. Moving targets require
quite different strategies than stationary ones. Strategies may also be adap-
tive depending on the results of areas searched and dynamically changing
resources.

4. VALUE TO FLEET: Fleet/area commanders would have the capability to perform
a variety of searches, under varying conditions and constraints with an educated
estimate of probability of success for a given time. He can also ascertain
the effect of committing additional resources to the task.

APPLICATION 38

1. TITLE: ENVIRONMENTALLY INFLUENCED SAILING DIRECTION

2. TECHNOLOGY: Distributed Data Bases, Navigation, Production Rules

3. APPLICATION DEFINITION: Route ships to avoid storms, high sea states, land masses, avoid detection, conserve fuel, certain ship classes containing deck cargo cannot sail in sea states greater than k or cannot fit through the Panama Canal. This program would be required to access a variety of data bases (weather, geographical, etc.) and computer programs (sailing directions computation, detection profiles, satellite ephemerides, etc.,) and to display optimal and sub-optimal sailing courses for the commanders' approval. Sailing times would also be computed.

4. VALUE TO FLEET: Based on weather, intelligence and other timely information a force commander or fleet cinc can use this program for both mission planning and execution.

APPLICATION 39

1. TITLE: SENSOR MANAGEMENT/TASKING

2. OPERATIONAL FUNCTION: Operational Planning, Resource Availability Planning

3. TECHNOLOGY: Query Language, Distributed Data Base

4. APPLICATION DEFINITION: The tasking of sensors by the operational commander which are not in his direct purview of authority can be supported by knowledge of sensor capability, position, and performance status. The management function further requires correct procedures and routing for tasking requests. The decision to request employment of an overhead photographic reconnaissance platform to support mission objectives can be reinforced by knowledge of sensor parameters in terms of availability, time of arrival, time of information availability, expect accuracy/resolution, etc.

5. APPROACH:

   a. Develop data base of sensor capabilities and status.

   b. Apply query language and computational routines to assist in utilization decision.

   c. Develop guidance assist for requesting sensor employment.

APPLICATION 40

1. <u>TITLE</u>: SENSOR OPTIMIZATION

2. <u>OPERATIONAL FUNCTION</u>: Operational Planning, Computational Support

3. <u>TECHNOLOGY</u>: Query Language

4. <u>APPLICATION DEFINITION</u> : The performance of own-force sensors is dependent on the environmental conditions in which they operate as well as the status of the individual sensors. Coverage areas of in-place sonobuoys as a function of the sea environment is one example. Sensors are also subject to mutual interference. The optimization process consists of sensor assessment, selection and employment.

5. <u>APPROACH</u>:

    a. From a data base consisting of sensor capability, status, location, and schedule, a query technique will allow quick assessment of resource availability and best application.

    b. Computational routines will be applied to sensor configurations for best placement. The routines are determined according to the nature of the sensor, its position in the sensor field, and its sensitivity to environment.

APPLICATION 41

1. <u>TITLE</u>: TACTICAL EM UTILIZATION

2. <u>OPERATIONAL FUNCTION</u>: Operational Planning

3. <u>TECHNOLOGY</u>: Query Language, Decision Aids

4. <u>APPLICATION DEFINITION</u>: The optimum utilization of the electromagnetic spectrum is dependent on the awareness of the needs of the platform functional tasks (e.g. detection, location, identification, information transfer, counter-measures, etc.), the nature of the threat to the EM operation, the character-istics of the EM self-interference (EMI), and the availability of monitor and control techniques.

5. <u>APPROACH</u>:

   a. Develop data base of typical EM radiation and reception equipment and capabilities.

   b. Develop data base of interference characteristics.

   c. Develop decision aids which assist first level judgment of appropriate platform EM profile for given scenario conditions.

   d. Provide computation routines which support queries for alternative EM profiles to meet changing tactical conditions.

APPLICATION 42

1. TITLE: MAN/SYSTEM INFORMATION COUPLERS

2. OPERATIONAL FUNCTION: Display Support

3. TECHNOLOGY: Human Factors, Computer Science

4. APPLICATION DEFINITION: The general term of cognitive aspects deals with the sensory capabilities of audio, visual, and tactile perception. The optimum C^2 decision making is a system problem wherein best ways of routing, displaying and using information are a function of the environment in which the commander operates. Aspects of modularity and flexibility in organization of information display are more important than any other factor in maintaining continuity of capability from commander to commander and situation to situation.

5. CAPABILITY GOALS:

    a. Determine the optimum modes of coding information for display to enhance human comprehension: shape, color, size, orientation, intensity variation, and others.

    b. Determine the optimum means of coupling information elements to the human decision maker as a function of the operational environment. Factors such as graphic, alpha-numeric, tabularized geographic plot, narrative voice, audible alarm, large group display, and microform are considered.

APPLICATION 43

1. <u>TITLE</u>: FORCE DIRECTION

2. <u>OPERATIONAL FUNCTION</u>: Execution

3. <u>TECHNOLOGY</u>: Decision Aids, Query Language

4. <u>APPLICATION DEFINITION</u>: The assignment of resources to carry out the operational plan is done via operational orders and directives which are usually manifested through electronic message distribution. The acknowledgement of such orders and the subsequent response of the tasked forces is vital to the C^2 process. This application concerns improving the timeliness of distribution, improving the accuracy of the bookkeeping related to reporting feedback, and providing an input for display of force situation status.

5. <u>CAPABILITY GOALS</u>:

    a. Provide message preparation aids which relate the operational plan to the specific characteristics (location, means of transmission, acknowledgement procedure, etc.) of the assigned platform.

    b. Provide techniques for setting threshold limits for acknowledgement times, setting of critical junctures in time and position of forces, and accommodating changes in force status with respect to platform or element capability.

6. <u>APPROACH</u>:

    a. Develop data base of critical parameters of assigned resources.

    b. Develop query language techniques to access the resource allocation data base and prepare message composition.

    c. Develop decision aids which allow automatic setting of threshold limits dependent on situation unique characteristics.

    d. Develop dynamic status indicators in alpha-numeric or geo display elements.

7. <u>RELATED APPLICATIONS, OTHER EFFORTS</u>: This application uses RA "Message Preparation Aid" as input.

APPLICATION 44

1. TITLE: SIMULATION EXERCISE

2. OPERATIONAL FUNCTION: Training Support

3. TECHNOLOGY: Query Language, Heuristic Programming, Decision Aids

4. APPLICATION DEFINITION: The training function can be organized towards improving skill levels of the team (scenario simulation and gaming) or towards that of the individual (job performance aids). This application addresses the improvement of indoctrination and training of the individual in one or more predefined watch positions of a command control node. Application of computer aided instruction techniques to predetermined scenario conditions and utilizing the set of applications tools will minimize user effectiveness.

5. APPROACH:

   a. Define the training goals and the curriculum required to support them.

   b. Develop self-contained "scenarios" which pertain to the trainee station.

   c. Examine and evaluate alternative application tools, e.g. heuristic programming and query langauge, in terms of improved comprehension of function and improved timeliness of response on the part of the operator.

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